

FORM PTO-1390 (Modified) (REV 11-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER A-7647	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371				U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.5) <div style="font-size: 1.5em; font-weight: bold; text-align: center;">10/069959</div>	
INTERNATIONAL APPLICATION NO. PCT/EP00/08543		INTERNATIONAL FILING DATE 1 September 2000 (01.09.2000)		PRIORITY DATE CLAIMED 15 September 1999 (15.09.1999)	
TITLE OF INVENTION METHOD FOR COMPRESSING A DIGITAL IMAGE WITH SEVERAL BIT PLANES					
APPLICANT(S) FOR DO/EO/US Christoph MEINEL and Serguei KHLOUDOV					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:					
<ol style="list-style-type: none"> 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (24) indicated below. 4. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31). 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371 (c) (2)) <ol style="list-style-type: none"> a. <input checked="" type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> has been communicated by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US) 6. <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> a. <input checked="" type="checkbox"/> is attached hereto. b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4) 7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3)) <ol style="list-style-type: none"> a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)) 9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)). 10. <input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)). 11. <input checked="" type="checkbox"/> A copy of the International Preliminary Examination Report (PCT/IPEA/409). 12. <input checked="" type="checkbox"/> A copy of the International Search Report (PCT/ISA/210). <p>Items 13 to 20 below concern document(s) or information included:</p> <ol style="list-style-type: none"> 13. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98 14. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 15. <input type="checkbox"/> A FIRST preliminary amendment. 16. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 17. <input type="checkbox"/> A substitute specification. 18. <input type="checkbox"/> A change of power of attorney and/or address letter. 19. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825. 20. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). 21. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). 22. <input type="checkbox"/> Certificate of Mailing by Express Mail 23. <input type="checkbox"/> Other items or information: 					

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24. The following fees are submitted: BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :				CALCULATIONS PTO USE ONLY	
<input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO				\$1040.00	
<input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO				\$890.00	
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<input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)				\$710.00	
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ENTER APPROPRIATE BASIC FEE AMOUNT =				\$890.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).				\$0.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	19 - 20 =	0	x \$18.00	\$0.00	
Independent claims	2 - 3 =	0	x \$84.00	\$0.00	
Multiple Dependent Claims (check if applicable). <input type="checkbox"/>				\$0.00	
TOTAL OF ABOVE CALCULATIONS =				\$890.00	
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2				\$445.00	
SUBTOTAL =				\$445.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).				\$0.00	
TOTAL NATIONAL FEE =				\$445.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3 28, 3.31) (check if applicable). <input type="checkbox"/>				\$0.00	
TOTAL FEES ENCLOSED =				\$445.00	
				Amount to be: refunded	\$
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a. ☒ A check in the amount of \$445.00 to cover the above fees is enclosed.

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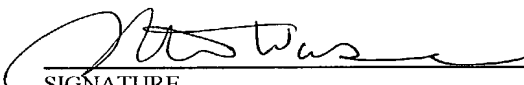
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NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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METHOD FOR COMPRESSING A DIGITAL IMAGE
WITH SEVERAL BIT PLANES

BACKGROUND OF THE INVENTION

Field of the Invention:

[001] This invention relates to a process for compression of a digital image with video information coded in several bit planes. The invention relates furthermore to a process for transmission of a digital image with video information coded in several bit planes, from the terminal of a sender to the terminal of a recipient.

Discussion of the Prior Art:

[002] The prior art discloses a plurality of different processes for storing digital images, especially photographs and drawings, in a video file which can be read by a computer. All these known processes use compression processes to make the video file as small as possible so that it requires as little storage space as possible in the main memory and on storage media of the computer. Moreover digital images can be transmitted more quickly from the terminal of a sender to the terminal of a recipient, the smaller the video file. The terminals are usually computers, but it is also conceivable to use telephones or the like equipped with the necessary hardware and software. The compression of digital images is important especially in modern medical technology where the images of modern computer diagnostic devices (for example, nuclear spin tomograph, x-ray machine, computer tomograph, etc.) are increasingly in digital form for storage or transmission to other computers.

[003] Some of the processes for compression of a digital image known from the prior art are for example the Windows Bit Map (BMP) format which is used especially by smaller graphics programs which can run under Windows. The PCX format and the Windows Metafile (WMF) format is likewise used by Windows applications, especially for Cliparts and other mapping. The

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Tagged Image File Format (TIF) process is used by a plurality of graphics programs for storing digital images. The Graphics Interchange Format (GIF) process and the Joint Photographic Experts Format (JPEG) process are used especially on the Internet for transmitting digital images. These known compression processes are generally available in modern browsers which are used for transmission of data files between computers and can be used when necessary.

[004] The BMP, WMF, PIF, GIF format is used for image description. The Huffmann, Shannon, Fano, arithmetic, LZW, LZ77, LZ78, JPEG, fractal, scalar or vector quantization process is used for compression.

[005] Some less common formats for image display of a digital image include the Computer Graphics Metafile (CGM) process, the Encapsulated Postscript (EPSI/EPST) process, the Group-4-Type 1 (G4 CCITT) process, the Portable Bitmap (PBM) process, the Portable Greymap (PGM) process, the Portable Network Graphics (PNG) process, the Portable Pixmap (PPM) process, the Silicon Graphics (RGB) process, the Sun Raster (SUN) process and the Group-4-Type-II (TG4 CCITT) process. Detailed information on the topic of compression of digital images can be taken from the Internet on the page <http://www.cs.cmu.edu/~guyb/real-world/compress/index.html> (status 9/13/99, last changed on 7/21/99).

[006] Each of these known processes for compression of a digital image for certain digital images achieves an especially high compression rate, while for other images it is less well suited. The GIF process is used preferably for drawings and artistic renderings. In the GIF process, the digital images are compressed via a change of the color or gray level information and not via the actual colors or gray levels. That is, the compressed video file is smaller, the fewer color and gray level changes the digital image contains, i.e. the larger the areas of the same color or gray level it contains. The GIF process works with 8-bit definition (color or gray level depth) per pixel. Based on this relatively low definition, it can happen, especially for photographic images, in the compressed video file

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that certain colors or gray levels are blurred or are built up from several colors or gray levels of the available palette; this can be recognized for a viewer of the compressed image in the relative coarse grain of the picture. Since the GIF process stores the information of a digital image via changing the colors or gray levels, when a photograph is compressed with high-definition changing of the colors or gray levels or with numerous colors or gray levels a major increase in the size of the compressed video file can occur. More detailed information on the GIF process can be found on the Internet on page <http://www.rit.edu/~mpb9954/mmwww/GIFComp.htm> (status 9/1/99, last changed on 9/22/97) and the page <http://www.cs.cmu.edu/~guyb/real-world/compress/index.html> (status 9/13/99, last changed on 7/21/99).

[007] The JPEG process is used preferably for photographs or other high definition images. In contrast to the GIF process, the JPEG process at a high level of fine detail leads to a relatively high compression rate. In any case, the JPEG process does not work as efficiently in digital images which contain large areas of the same color or gray level, since it adds additional information within and around these surfaces, allowing the image to appear unclear. More detailed information on the JPEG process can be found on the Internet on page <http://www.rit.edu/~mpb9954/mmwww/JPEGComp.htm> (status 9/1/99, last changed on 9/22/97) and the page <http://www.cs.cmu.edu/~guyb/real-world/compress/index.html> (status 9/13/99, last changed on 7/21/99).

[008] Comparison of these two compression processes taken for example from known compression processes clearly shows that certain compression processes for certain digital images can achieve a better compression rate than for other digital images. Since digital images generally have image areas of any configuration (for example, large areas of the same color or gray level on the one hand and high-definition changes and many colors or gray levels on the other), the choice of a single compression process for a digital image generally represents only a compromise for a digital image.

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[009] For this reason, in the prior art, so-called adaptive compression processes are used which analyze the image areas of a digital image for its configuration and depending on the analysis results for different areas of the image, use different compression processes.

[010] Three different adaptive compression processes are known from the prior art:

[011] The first group of adaptive compression processes contains local adaptive algorithms. The digital image is first segmented into non-overlapping image areas. Accordingly, each area is coded by a suitable compression process with which a compression rate as high as possible can be achieved with minimum loss of information, or even without loss of information.

[012] The second group contains algorithms which, depending on the local properties of the image, change their parameters, for example the code book in vector quantization or the parameters of the quantization matrix in the JPEG process or in Huffmann coding. The digital image is then coded by a compression process with locally varying parameters.

[013] The third group contains algorithms which determine the global properties of the image and based on these global properties choose the most effective compression process. Accordingly the entire digital image is coded by the chosen compression process.

[014] It is common to all these adaptive compression processes known from the prior art that the digital image to be compressed is segmented into several local image areas and the different compression processes are then applied to the individual image areas.

SUMMARY OF THE INVENTION

[015] The object of this invention is to devise a novel process for compression of a digital image which enables compression as efficient as possible for digital images of any configuration, i.e. with as little computer cost as possible can achieve a compression rate as high as possible.

[016] To achieve this object, proceeding from the process of the initially mentioned type, the present invention proposes a process which is characterized by the following steps:

- analysis of the bit planes of the digital image;
- subdivision of the bit planes of the digital image into several bit plane areas which each have at least one bit plane;
- division of the digital image into several bit plane area images which each have one of the bit plane areas;
- selection of a certain compression process for each bit plane area image; and
- compression of the individual bit plane area images with the compression process chosen at the time.

[017] The digital image to be compressed is not, as is known from the prior art, segmented into several image areas which each have the same bit planes as the digital image. Therefore it is not the contents of the digital image which are analyzed, but rather its bit planes.

[018] The bit planes of the digital image are subdivided depending on the analysis results into several bit plane areas. The digital image is divided into several bit plane area images which each comprise one of the bit plane areas. For each bit plane area image, depending on the result of analysis of the bit planes of the digital image, a certain compression process is chosen.

[019] The bit planes of the digital image can be analyzed for example with respect to a compression rate as high as possible, loss of image content in the reconstructed image as low as

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possible, or computer costs as low as possible. The compression methods used are preferably chosen from the conventional compression processes ordinarily contained in a browser. Finally, the individual bit plane area images are compressed with the compression process chosen at the time.

[020] Using analysis of the bit planes of the digital images to be compressed, the bit planes are thus subdivided into certain bit plane areas, the digital image is divided into certain bit plane area images and for each bit plane area image, a suitable compression process is chosen. The process as claimed in the invention for compression of a digital image enables especially efficient compression of the digital image. With a comparatively low computer cost, especially high compression rates with extremely low or even no loss at all of image contents can be achieved.

[021] According to one advantageous development of this invention it is proposed that the image planes of the digital image are subdivided into two bit plane areas and the digital image is divided into two bit plane area images. For the first bit plane area which comprises the high-order bit planes, the GIF compression process is chosen, and for the second bit plane area which comprises the low-order bit planes, the JPEG compression process is chosen and the bit plane area images are compressed with the compression process chosen at the time. The GIF and JPEG processes are two compression processes which as already explained, complement one another especially well. Where one compression process has disadvantages, the other compression process works especially well and vice versa. By using these two compression processes an especially efficient compression of a digital image is enabled. Moreover, the GIF and JPEG compression processes are conventional compression processes which are contained in almost any modern browser and can be retrieved there at any time.

[022] By analyzing the bit planes of the digital image and dividing the digital image into bit plane area images an especially efficient division of the digital image into areas which are compressed with the GIF compression process, and into

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areas which are compressed with the JPEG compression process, becomes possible. This efficient division of the digital image could not be achieved by simple analysis of the image contents of the digital image. In the high-order bit planes, mainly the image contents of the digital image, and in the low-order bit planes mainly the noise of the digital image are contained. The high-order bit planes are compressed with the GIF process and the low-order bit planes including the noise are compressed with the JPEG process.

[023] According to one preferred embodiment of this invention, it is proposed that the analysis of the bit planes of the digital image comprises the following steps:

- division of the digital image into several bit plane images which each comprise one bit plane;
- generation of analysis images by superposition of several bit plane images, beginning at the bit plane images which comprise the two highest-order bit planes, for the first analysis image and by addition of the bit plane image which comprises the next lower bit plane for each additional analysis image;
- segmentation of the analysis images into segments which each have the same pixel values;
- determination of the areas of the segments;
- finding the average of the segment areas of one analysis image;
- determining the compression factor as a function of the average of the segment areas when using a certain compression process;
- determination of the analysis image in which the compression factor when using a certain compression process is greater than a given boundary value factor; and
- determination of the bit plane areas as a function of those bit planes which are comprised by the determined analysis image.

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[024] Advantageously, proceeding from the analysis image which comprises the bit plane images with the highest-order bit planes, that analysis image is determined in which the compression factor when using a certain compression process is greater than 10. This applies especially to the LZW process according to which the digital images are compressed in the GIF format.

[025] The individual analysis images are segmented into segments which each have the same pixel values, i.e. the same colors or gray levels. If the areas of the segments of one analysis image have a relatively large area, a compression process which is designed for large area digital images of the same color or gray level, such as for example the GIF process, is much better suited for compression of this analysis image than a compression process which is designed for high-definition digital images with a high level of fine detailing and a host of different colors and gray levels, such as for example the JPEG process.

[026] The process according to this embodiment enables division of the digital image into several bit plane area images which comprise exactly those bit planes of the digital image such that they are compressed when using a suitable compression process with a compression factor which is greater than a given boundary value factor, preferably greater than 10. Since the compression factor of certain compression processes, for example of the GIF compression process, is dependent on the average of the segment surfaces of the analysis images, the compression factor in this embodiment can be quickly and reliably determined with great ease. Preferably the bit planes of the digital image are subdivided into bit plane areas such that when using a certain compression process, a compression factor greater than 10 is achieved. If several compression processes achieve a compression factor greater than 10, that process is determined which has the lowest computation cost or the highest compression factor.

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[027] According to another preferred embodiment of this invention it is proposed that before compressing the first bit plane area image which comprises the high-order bit planes, the direction of the GIF compression process is determined with which the highest compression rate can be achieved. The direction of the GIF compression process is preferably determined using the following steps:

- division of the digital image into several bit plane images which each comprise one bit plane; and
- generation of analysis images by superposition of several bit plane images, beginning at the bit plane images which comprise the two highest-order bit planes, for the first analysis image, and by adding the bit plane image which comprises the next lower bit plane for each additional analysis image;
- segmentation of the analysis images into segments which each have the same pixel values;
- determination of the vertical side lengths and of the horizontal side lengths of the segments;
- finding the average of the vertical side lengths and the horizontal side lengths of one analysis image;
- comparison of the average of the vertical side lengths to the average of the horizontal side lengths of one analysis image; and
- determination of the direction of the GIF compression process from the result of comparison of the averages of the side lengths.

[028] According to one advantageous development of this invention, it is proposed that the second bit plane area image which comprises the low-order bit planes, is classified before compression into an object area and into a background area. The object area comprises one or more objects which are to be represented in the digital image. The background area is independent of the object to be represented or each such object, and has no effect on the representation of the object. Without

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loss of quality of the reconstructed image, the compression factor of the compression process can be increased when the background is simplified, i.e. has lower definition and/or fewer colors or gray levels.

[029] According to one preferred embodiment of this invention, it is proposed that the classification of the second bit plane image area is done using the following steps:

- segmentation of the first bit plane area image which comprises the high-order bit planes into a plurality of pixel blocks;
- segmentation of the pixel blocks into segments which each have the same pixel values;
- determination of the number of different segments with different pixel values within a pixel block;
- classification of a pixel block as the object region if the pixel block contains different segments;
- otherwise, classification of the pixel block as the background area; and
- classification of the second bit plane area image which comprises the low-order bit planes into the corresponding object area and background area.

[030] According to another preferred embodiment of this invention, the background area of the second bit plane area image which comprises the low-order bit planes is replaced by a background consisting of square pixel blocks, all pixels of a pixel block having the same pixel value. The values of all pixels of a pixel block are advantageously equivalent to the average of the pixel values of the pixel block. Preferably the background area is replaced by a background consisting of pixel blocks with a size of 8 x 8 pixels. By these measures for simplification of the background region, the compression factor of the JPEG compression process can be further increased without loss of quality of the image information of the reconstructed image.

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[031] According to another advantageous development of this invention, it is suggested that before compressing the second bit plane area image which comprises the low-order bit planes the parameter Q for the JPEG compression process is determined.

[032] According to one preferred embodiment of this invention it is proposed that the parameter Q is determined depending on the number of bit plane images of the second bit plane area image which contain video information.

[033] It is furthermore suggested that the parameter Q is advantageously determined using the following steps:

- division of the digital image into several bit plane images which each comprises one bit plane of the digital image;
- segmentation of the bit plane images of the second bit plane area image which comprises the low-order bit planes into segments which each have the same pixel values;
- determination of the areas of the segments;
- finding the average of the segment areas of a bit plane image; and
- proceeding from the highest-order bit plane image of the second bit plane image area, determination of the number of bit plane images, in which the difference of the average of the segment area of this bit plane image and of the average of the segment areas of the lowest-order bit plane image is greater than 10% of the average of the segment areas of the lowest-order bit plane image.

[034] The relationship between the determined number of bit plane images and the parameter Q is computed by static modelling for each JPEG version.

[035] According to another advantageous development of this invention, it is proposed that the bit plane area images compressed with different compression processes are combined into a compressed video file, in the header lines of which information about the size of the individual bit plane area images is written. The header line therefore contains information about where the boundaries between the individual bit areas were drawn during compression.

[036] Advantageously, into the header lines of the video file information is also written about which bit plane area image was compressed with which compression process. Using the information written into the header line a compressed video file can be easily broken down at a later time again into compressed bit plane area images and the individual bit plane area images can be decompressed with the corresponding decompression process.

[037] Another object of this invention is to devise a process for transmission of a digital image of the initially mentioned type which enables transmission of the digital image as fast as possible for digital images of any form, i.e. in photographs as well as in drawings.

[038] To achieve this object, proceeding from the process for transmission of a digital image of the initially mentioned type, the invention suggests a process which is characterized by the following steps:

- compression of the digital image on the computer of the sender using a process in which header lines include information about the size of individual bit plane area images as well as information about which bit plane area image was compressed with which compression process;
- transmission of the compressed video file from the terminal of the sender to the terminal of the recipient;
- reception of the compressed video file on the terminal of the recipient;
- analysis of the header line of the compressed video file on the terminal of the recipient;
- breakdown of the compressed video file into compressed bit plane area images;
- decompression of the bit plane area images with the corresponding decompression processes on the terminal of the recipient; and
- superposition of the decompressed bit plane area images onto the digital image on the terminal of the recipient.

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[039] According to one advantageous development of this invention, it is proposed that with the compressed video file, a software program which can run on the terminal of the recipient is also transmitted which analyzes the header line of the compressed video file, controls the breakdown of the compressed video file and the decompression of the compressed bit plane area images and executes superposition of the decompressed bit plane area images onto the digital image.

[040] Advantageously the software program is made as Java applet which can run in the browser of the terminal of the recipient.

BRIEF DESCRIPTION OF THE DRAWINGS

[041] One preferred embodiment of this invention is detailed below using the drawings.

[042] FIGURE 1 shows a flowchart of the process of the present invention for compression of a digital image according to one preferred embodiment;

[043] FIGURE 2 shows the division of the digital image into several analysis images;

[044] FIGURE 3 shows the segmentation of the analysis images; and

[045] FIGURE 4 shows the division of the digital image into two bit plane area images.

DETAILED DESCRIPTION OF THE INVENTION

[046] The process as claimed in the invention is an adaptive compression process for digital images with video information coded in several bit planes. Different than the compression processes known from the prior art, the contents of the digital image are not analyzed. Therefore, the digital image to be compressed is not segmented into several image areas with each having the same bit planes as the digital image. Rather the digital image in the process of the present invention is analyzed using its bit planes, and then, depending on the analysis result, suitable compression processes for certain bit planes are selected.

[047] A flow chart of the process as claimed in the invention is shown in Figure 1. The digital image DB (block 1) to be compressed is the recording of a computer diagnostic device from medicine. The digital image DB has twelve bit planes BE in which the video information is coded, i.e. each pixel of the digital image DB has 12 bits. The processes executed subsequently in

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block 2 are detailed in Figure 2 for explanation. In block 2, the digital image DB is divided into twelve bit plane images BEB which each comprise one bit plane BE. Then analysis images AB are generated from the bit plane images BEB. To generate the first analysis image AB1, the two bit plane images BEB1 and BEB2 are superimposed with the highest-order bit planes BE1 and BE2. For the next analysis image AB2 the bit plane image BEB3 with the next lower bit plane BE3 is superimposed on the first analysis image AB1. To generate the other analysis images AB3 to AB11 the process proceeds in a similar manner such that finally eleven analysis images AB are generated from the twelve bit plane images BEB.

[048] Then, in block 3 the analysis images are segmented into segments which each have the same pixel values, i.e. the same color or gray level. This process is shown in greater detail in Figure 3 for explanation. As shown in the left portion of Figure 3, an analysis image AB is taken, for example, and an area of the analysis image AB on the right is shown enlarged. The individual segments in this area are identified with S1 to S9. Then, still in block 3, the areas of the individual segments are determined. The segment S1 has for example an area of 7 and segment S8 an area of 34. Finally, the averages of the segment areas of each analysis image AB are formed.

[049] There is a relationship between the average value of the segment surfaces and the compression factor of the GIF compression process. Based on this relationship, in blocks 4 to 6, beginning at the highest-order bit plane, the number n of bit planes BE is computed in which the condition that the compression factor in the compression of an analysis image AB with a certain compression factor is greater than 10 is still correct.

[050] The blocks 4 to 6 yield a boundary value on which the bit planes BE of the digital image DB are divided into a low-order bit plane area and into a high-order bit plane area. The digital image DB is then divided into a first bit plane area image BEBB1 which comprises the bit plane area with the high-order bit planes BE1 to BE4, (block 7) and into a second bit plane area image BEBB2 which comprises the bit plane area with

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the low-order bit planes BE5 to BE12 (block 8). The first bit plane area image BEBB1 corresponds to the analysis image A3 which comprises the bit plane images BEB1 to BEB4 with the corresponding bit planes BE1 to BE4. The second bit plane area image BEBB2 corresponds to the difference of the digital image DB and the first bit plane area image BEBB1. The division of the digital image DB into the first and the second bit plane area image BEBB1 and BEBB2 is illustrated in Figure 4. For the first bit plane area image BEBB1 the GIF compression process is selected and for the second bit plane image area BEBB2, the JPEG compression process.

[051] In block 9 the direction of the GIF compression process with which the highest compression rate can be achieved is determined. To do this, the vertical side lengths and the horizontal side lengths of the segments of the analysis images AB are determined (compare Figure 3). The segment S1 has for example a vertical side length (height) of 2 and a horizontal side length (width) of 4 and the segment S8 has a height of 4 and a width of 12. Then the average value of the vertical side lengths and of the horizontal side lengths of each analysis image AB is formed. From comparison of the average of the vertical side lengths to the average of the horizontal side lengths of each analysis image AB, finally the direction of the GIF compression process is formed.

[052] In the blocks 10 to 12 the number k of bit planes BE of the second bit plane area image BEBB2 which contain video information is determined. It is assumed that the bit plane BE contains video information when the peak signal-to-noise ratio (PSNR) is greater than 40 dB, i.e. when the difference between the average value of the segment areas of this bit plane image BEB and the average of the segment area of the lowest-order bit plane image BEB12 is less than 10% of the average of the segment areas of the lowest-order bit plane image BEB12. Proceeding from the highest-order bit plane of the second bit plane area image this is checked in block 11.

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[053] In block 13 the parameter Q for the JPEG process is determined. The parameter Q is determined depending on the number k of bit planes BE5 to BE12 of the second bit plane area image BEBB2 which contain video information.

[054] Then, the second bit plane area image BEBB2 in block 14 is classified into an object area and into a background area. To do this, the first bit plane area image BEBB1 is segmented into a plurality of pixel blocks. The pixel blocks are for their part segmented into segments which each have the same pixel values. Then the number of different segments with different pixel values is determined within one pixel block at a time. One pixel block is classified as an object area if the pixel block contains different segments with two or more different pixel values. Otherwise, the pixel block is classified as a background area. The second bit plane area image BEBB2 is then classified into a corresponding object area and a background area.

[055] To increase the compression rate, the background area is replaced by a background consisting of quadratic pixel blocks with a size of 8 x 8 pixels. All pixels of a pixel block have the same pixel value, specifically the average of the pixel values of the pixel block.

[056] In block 15 the first bit plane area image BEBB1 in the direction determined in block 9 is compressed with the GIF compression process. Likewise, in block 16 the second bit plane area image BEBB2 is compressed with the parameter Q determined in block 13 and the background area which is simplified in block 14 with the JPEG compression process. The compressed bit plane area images are combined in block 17 into a compressed video file (block 18). In the header line of the compressed video file, information about the size of the individual bit plane area images and about the compression processes applied to the individual bit plane area images BEBB is written.

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CLAIMS

1. A process for the compression of a digital image (DB) with video information coded into several bit planes (BE), comprising the steps of:

analyzing the bit planes (BE) of the digital image (DB);

subdividing the bit planes (BE) of the digital image (DB) into several bit plane areas which each have at least one bit plane (BE);

dividing the digital image (DB) into several bit plane area images (BEBB) which each have one of the bit plane areas;

selecting a certain compression process for each bit plane area image (BEBB); and

compressing the individual bit plane area images (BEBB) with the compression process chosen at the time.

2. The process as claimed in claim 1, wherein said subdividing step subdivides said bit planes of the digital image into a first high-order bit plane and a second low-order bit plane, and further wherein said compressing step compresses said first high-order bit plane utilizing the GIF compression process and compresses said second low-order bit plane utilizing the JPEG compression process.

3. The process as claimed in claim 1, wherein said analyzing step comprises the steps of:

dividing said digital image (DB) into several bit plane images (BEB) which each comprise one bit plane (BE);

generating analysis images (AB) by superposition of several of said bit plane images (BEB), beginning at the bit plane images (BEBB1, BEBB2) which comprise the two highest-order bit planes (BE), for a first analysis image (AB1) and by addition of said bit plane images (BEB3...BEB12) which comprises the next lower bit plane (BE3...BE12) for each additional analysis image (AB2...AB11);

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segmenting said analysis images (AB) into segments (S) which each have the same pixel values;

determining the areas of said segments (S);

finding the average of said segment areas of one analysis image (AB);

determining a compression factor as a function of the average of the segment areas when using a certain compression process;

determining the analysis image (AB) in which the compression factor when using a certain compression process is greater than a given boundary value factor; and

determining the bit plane areas as a function of those bit planes (BE) which are comprised by the determined analysis image (AB).

4. The process as claimed in claim 3, wherein said step of determining the analysis image utilizes a compression factor great than 10.

5. The process as claimed in claim 2, wherein before compressing said first high-order bit plane, the direction of said GIF compression process is determined with which the highest compression rate can be achieved.

6. The process as claimed in claim 5, wherein the direction of said GIF compression process is determined using the following steps:

dividing the digital image (DB) into several bit plane images (BEB) which each comprise one bit plane (BE);

generating analysis images (AB) by superposition of several bit plane images (BEB), beginning at the bit plane images (BEB1, BEB2) which comprise the two highest-order bit planes (BE1, BE2), for the first analysis image (AB1), and by adding the bit plane image (BEB3...BEB12) which comprises the next lower bit plane (BE3...BE12) for each additional analysis image (AB2...AB11);

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segmenting said analysis images (AB) into segments (S) which each have the same pixel values;

determining the vertical side lengths and the horizontal side lengths of said segments (S);

finding the average of the vertical side lengths and the horizontal side lengths of one analysis image (AB);

comparing said average of the vertical side lengths to the average of the horizontal side lengths of each analysis image (AB); and

determining the direction of said GIF compression process from the result of the comparison of the averages of the side lengths.

7. The process as claimed in claim 2, wherein said second low-order bit plane is classified before compression into an object area and into a background area.

8. The process as claimed in claim 7, wherein the classification of said second low-order bit plane image area (BEBB2) is done using the following steps:

segmenting said first high-order bit plane area image into a plurality of pixel blocks;

segmenting said pixel blocks into segments which each have the same pixel values;

determining the number of different segments with different pixel values within a pixel block;

classifying a pixel block as the object region if the pixel block contains different segments;

classifying the pixel block as the background area if said pixel does not contain different segments; and

classifying said second low-order bit plane area image (BEBB2) into the corresponding object area and background area.

9. The process as claimed in claim 7, wherein the background area of said second low-order bit plane area image (BEBB2) is replaced by a background consisting of square pixel blocks, all pixels of a pixel block having the same pixel value.

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10. The process as claimed in claim 9, wherein the pixel values of all pixels of a pixel block are equivalent to the average of the pixel values of the pixel block.

11. The process as claimed in claim 9, wherein the background area is replaced by a background consisting of pixel blocks with a size of 8 x 8 pixels.

12. The process as claimed in claim 2, wherein before compressing said second low-order bit plane area image (BEBB2) the parameter Q for the JPEG compression process is determined.

13. The process as claimed in claim 12, wherein said parameter Q is determined depending on the number of bit plane images (BEB) of said second low-order bit plane area image (BEBB2) which contain video information.

14. The process as claimed in claim 13, wherein said parameter Q is determined using the following steps:

dividing said digital image (DB) into several bit plane images (BEB) which each comprises one bit plane (BE) of the digital image (DB);

segmenting said bit plane images (BEB) of said second low-order bit plane area image (BEBB) into segments (S) which each have the same pixel values;

determining the areas of said segments (S);

finding the average of the segment areas of a bit plane image (BEB) of the bit plane area image (BEBB2); and

proceeding from the highest-order bit plane image (BEB) of the second bit plane image area (BEBB2), determining the number of bit plane images (BEB), in which the difference of the average of the segment areas of this bit plane image (BEB) and the average of the segment areas of the lowest-order bit plane image (BEB12) is greater than 10% of the average of the segment areas of the lowest-order bit plane image (BEB12).

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15. The process as claimed in claim 1, wherein said bit plane area images (BEBB) compressed with different compression processes are combined into a compressed video file having header lines, said header lines including information about the size of the individual bit plane area images (BEBB).

16. The process as claimed in claim 15, wherein said header line of the compressed video file includes information about which bit plane area image (BEBB) was compressed with which compression process.

17. The process for transmission of a digital image (DB) with video information coded in several bit planes (BE) from the terminal of a sender to the terminal of a recipient, including the steps of:

- compressing the digital image (DB) on the terminal of the sender to provide a compressed video file including at least one header line;

- transmitting said compressed video file from the terminal of the sender to the terminal of the recipient;

- receiving said compressed video file on the terminal of the recipient;

- analyzing the header line of said compressed video file on the terminal of the recipient;

- breaking down said compressed video file into said compressed bit plane area images;

- decompressing bit plane area images with said decompressing step accomplished on the terminal of the recipient;
- and

- superpositioning the decompressed bit plane area images (BEBB) onto the digital image (DB) on the terminal of the recipient.

18. The process as claimed in claim 17, further including the steps of:

- transmitting a software program along with said compressed video file for running on the terminal of the recipient;

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analyzing said header line of said compressed video file for controlling the breakdown of said compressed video file and the decompression of compressed bit plane area images; and

executing the superposition of said decompression
bit plane area images onto the digital image.

19. The process as claimed in claim 18, wherein said software program is a Java applet which can run in the browser of the terminal of the recipient.

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ABSTRACT

The invention relates to a method of compressing a digital image (DB), whose image information is encoded on several bit planes (BE). The invention provides an adaptive compression method which allows the most efficient compression possible for digital images with any configuration. The method comprises the steps of analyzing the bit planes (BE) of the digital image (DB) into several bit plane areas, each containing at least one bit plane (BE), dividing the digital image (DB) into several bit plane areas images (BEBB), each containing one of the bit plane areas (block 7; block 8), selecting a specific compression method for each bit plane area image (BEBB), and compressing the individual bit plane area images (BEBB) using the respective compression method which has been selected (block 15; block 16).

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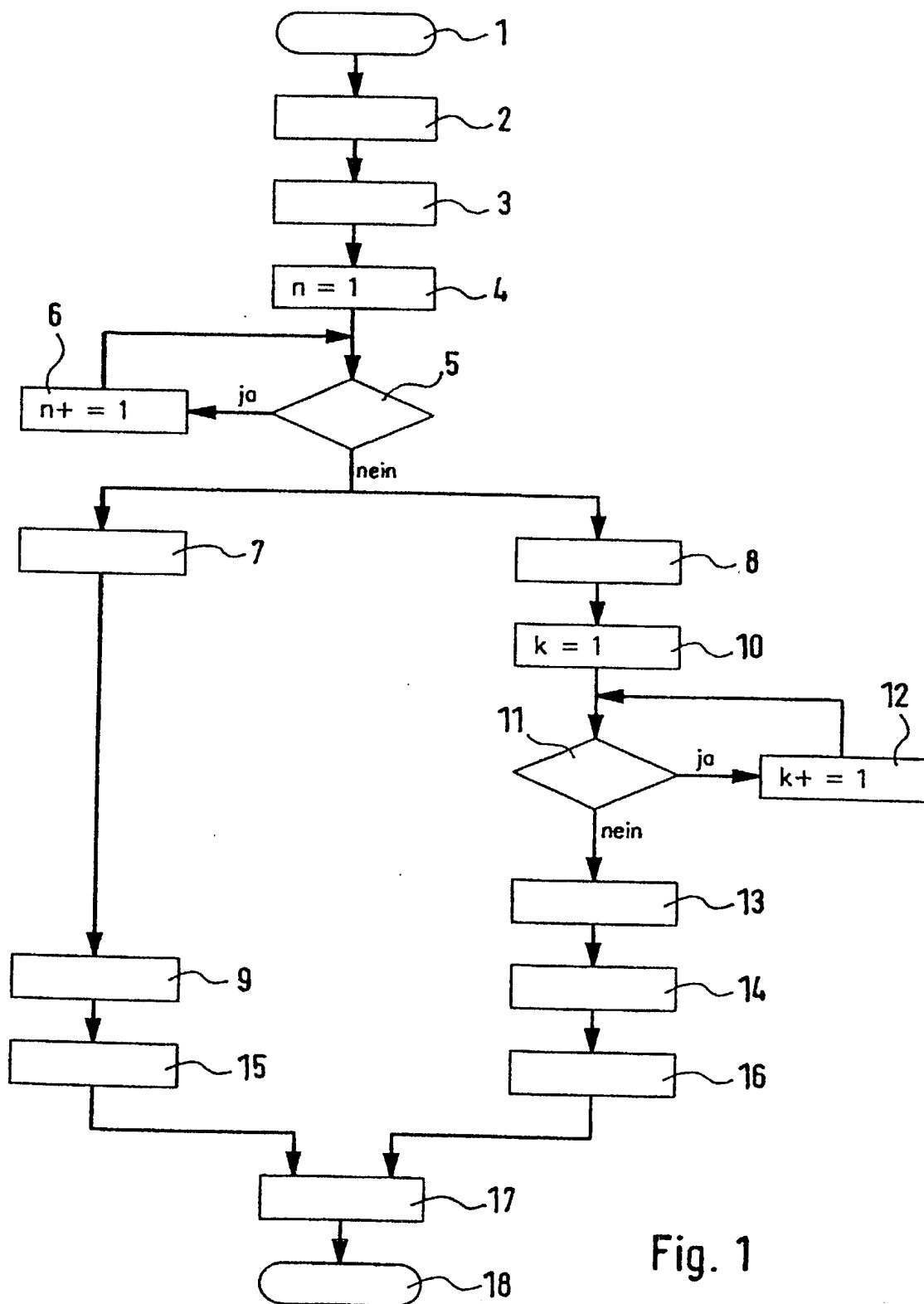


Fig. 1

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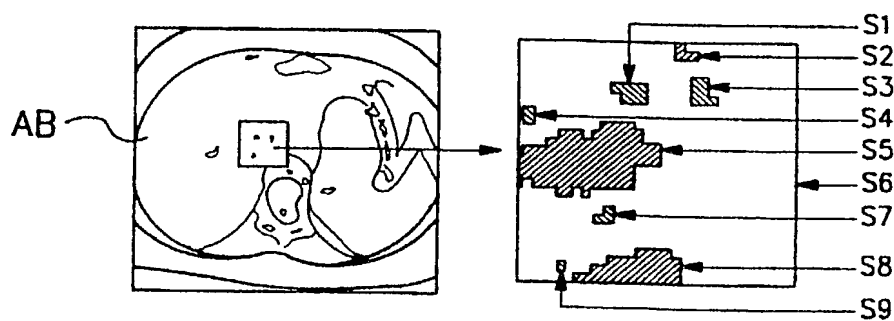
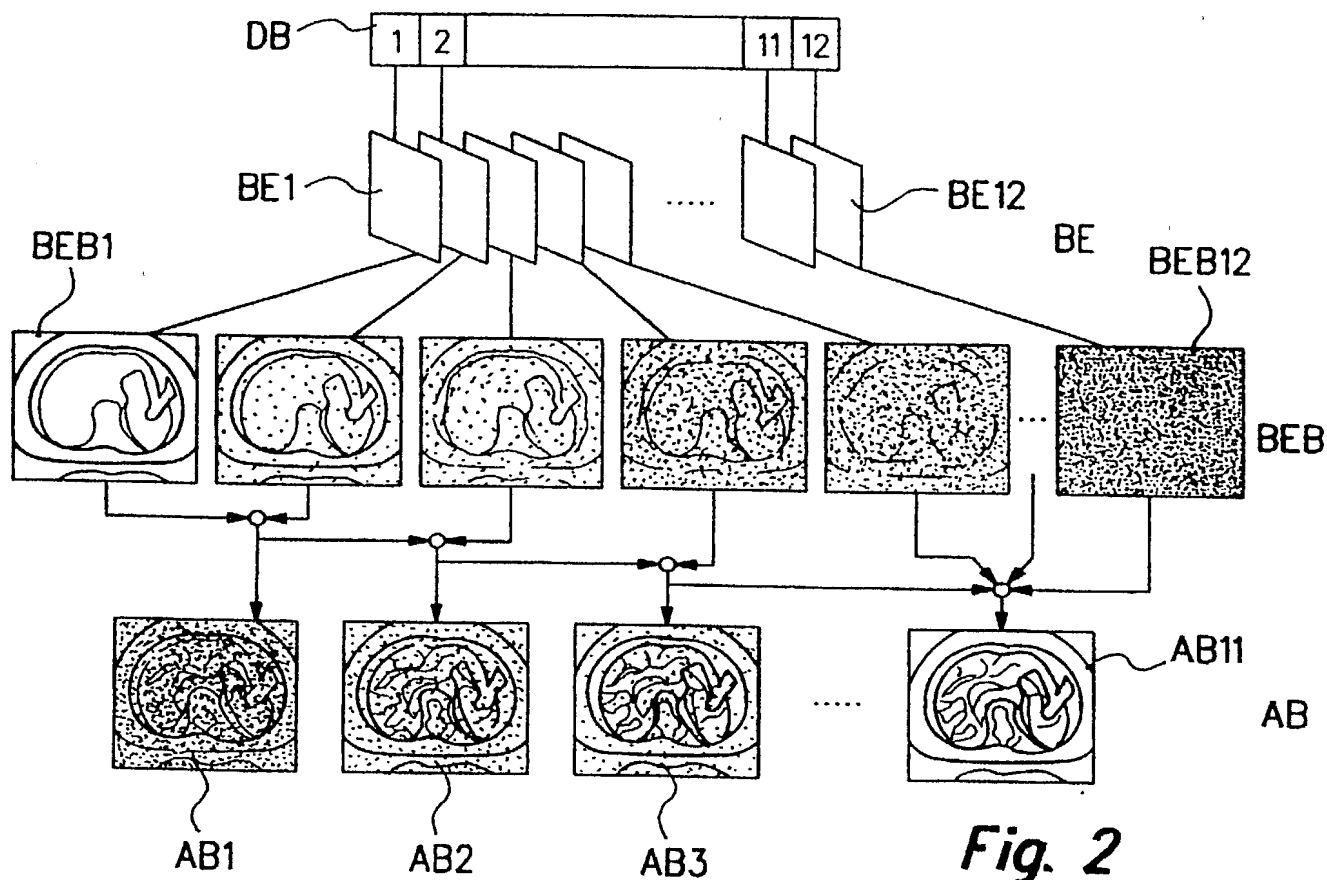
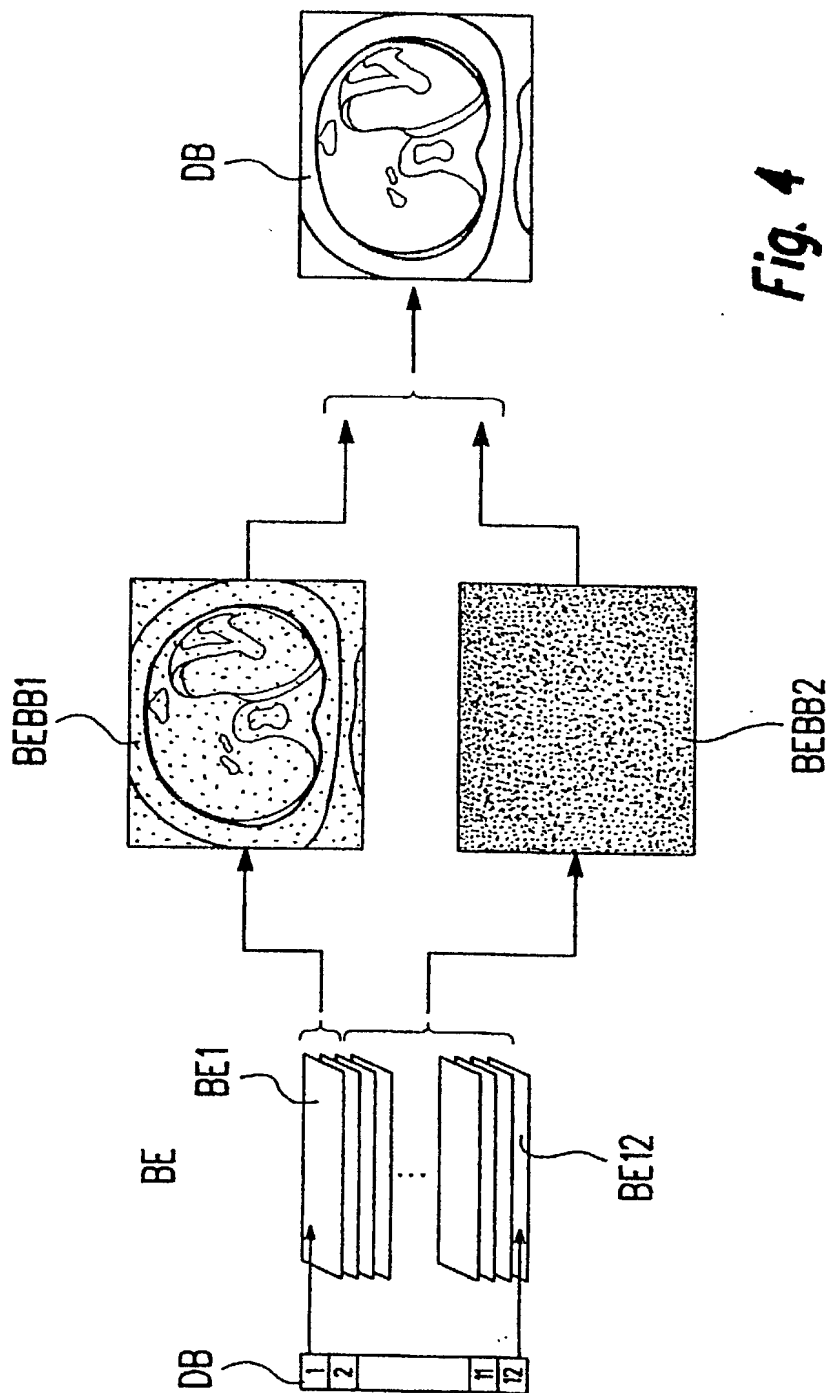


Fig. 3

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METHOD FOR COMPRESSING A DIGITAL IMAGE WITH SEVERAL BIT-PLANES

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Prior Foreign Applications
(Frühere ausländische Anmeldungen)

199 44 213.4	GERMANY
(Number)	(Country)
(Nummer)	(Land)

PCT/EP00/08543	PCT
(Number)	(Country)
(Nummer)	(Land)

Priority Not Claimed
Priorität nicht beansprucht

15 September 1999
(Day/Month/Year Filed)
(Tag/Monat/Jahr der Anmeldung)

1 September 2000
(Day/Month/Year Filed)
(Tag/Monat/Jahr der Anmeldung)

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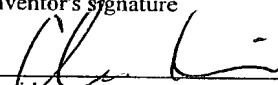

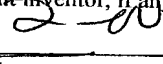
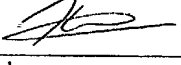

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